Journal of Siberian Federal University. Biology 2018 11(4): 288-293
~ ~ ~

УДК 574.633

In Search for Common Ground: Studies of Freshwater and Saline Lakes

Egor S. Zadereev*[a,b] and Nickolai V. Shadrin[c]
[a]Institute of Biophysics SB RAS
FRC "Krasnoyarsk Science Centre SB RAS"
50/50 Akademgorodok, Krasnoyarsk, 660036, Russia
[b]Siberian Federal University
79 Svobodny, Krasnoyarsk, 660041, Russia
[c]A.O. Kovalevsky Institute of Marine Biological Research RAS
2 Nakhimov, Sevastopol, 299011, Russia

Citation: Zadereev E.S., Shadrin N.V. In search for common ground: studies of freshwater and saline lakes. J. Sib. Fed. Univ. Biol., 2018, 11(4), 288-293. DOI: 10.17516/1997-1389-0072.

В поисках точек соприкосновения: исследования соленых и пресных озер

Е.С. Задереев[а,б], Н.В. Шадрин[в]
[а]Институт биофизики СО РАН
ФИЦ «Красноярский научный центр» СО РАН
Россия, 660036, Красноярск, Академгородок, 50/50
[б]Сибирский федеральный университет
Россия, 660041, Красноярск, пр. Свободный, 79
[в]Институт биологии южных морей
имени А.О. Ковалевского РАН
Россия, 299011, Севастополь, пр. Нахимова, 2

This special issue of the journal includes the papers presented in the August of 2017 at the 13th International Conference on Salt Lake Research (Ulan-Ude, Russia). The conference was organised by the International Society for Salt Lake Research (ISSLR), Institute of General and Experimental Biology SB RAS (Ulan-Ude), Institute of Biophysics SB RAS (Krasnoyarsk),

* Corresponding author E-mail address: egor@ibp.ru; snickolai@yandex.ru

Institute of Natural Resources, Ecology and Cryology SB RAS (Chita) and Buryat State University (Ulan-Ude) and brought together 120 researchers from 15 countries worldwide.

International conferences on saline lakes have been held since 1979. These are interdisciplinary events aimed at establishing contacts between researchers from different fields and sharing expertise on conservation and rational management of saline lake ecosystems. It is impossible to cover the whole range of the conference themes in a single issue. More papers are published in the special issue of the "Journal of Oceanology and Limnology" (Issue 6, Volume 36, 2018) but even taken together these two editions cannot provide enough room for all the issues raised. For this reason we find it essential to give a detailed review of the themes and topics addressed by the speakers.

A key aspect in exploring saline lakes is the study of the unique microorganisms that occur there. Many salt water bodies are extreme habitats. High salinity is only one of many stress factors in such ecosystems (Shadrin, 2018). Among other abiotic factors determining their extremity are high solar radiation and low temperatures in mountain lakes, high temperatures in thermal springs and hypersaline waters, hypoxic and anoxic conditions in meromictic and hypersaline lakes. Research into extremophilic and extremotolerant organisms able to live and reproduce in extreme natural environments is closely related to astrobiology. The unique biogeochemical ability of these organisms to involve sulphur, iron, manganese, uranium and other elements in biotic cycles deserves close attention on the part of geochemical and geophysical sciences. Identifying the unique genes which enable these organisms to resist a range of extreme conditions is of major importance for both a better understanding of the functions and adaptations of all life forms and for developing new biotechnologies (Oren, 2018).

The session on microbial extremophiles included presentations on extremophilic life forms in high-altitude lakes in the Andes (Chile), carbonate lakes in Transbaikal (Russia), Hungary and Romania, ephemeral lakes in Australia and North America and the deep-water parts of Lake Baikal. This session was dedicated to the memory of a well-known microbiologist, Honoured Scientist of the Russian Federation, head of the laboratory of microbiology in the Institute of General and Experimental Biology SB RAS (Ulan-Ude), doctor of science (biology) Bair Namsarayev, who passed on in 2015 (Namsaraev et al., 2015). In his plenary talk, Professor Vladimir Gorlenko (Moscow) spoke on the numerous contribution by Bair Namsarayev, his friend and colleague.

A series of presentations was devoted to biodiversity and ecology of eukaryotic organisms. In the context of ever growing global shortages of freshwater and food resources, the approaches to saline aquaculture are of particular interest and several speakers discussed them in their presentations.

Another topical issue was variations in the water level and salinity of lakes that result in alterations in aquatic ecosystems (Wurtsbaugh, Berry, 1990; Jeppesen et al., 2015; Golubkov et al., 2018). Many saline lakes are terminal (closed) basins. The level of water in such reservoirs depends on the ratio between water input and evaporation from the water surface. In some parts of the planet, e.g. those with a Mediterranean-type climate, precipitation and evaporation levels gradually change causing the climate to become more arid. As a result, lakes in such regions are currently changing or can be expected to change from an open to closed type (Jeppesen et al., 2015). In North America, winter treatment of motorways with de-icing reagents leads to large inputs of salt in the region's water bodies causing their salinisation (Thornton et al.,

2015; Dugan et al., 2017). Hence, the aspect of salinity is becoming important for freshwater ecologists too. To emphasise the importance of an interdisciplinary approach in limnology and to bring together freshwater and saline lakes researchers, the conference came up with a slogan «Studies of Saline and Freshwater Lakes: In Search for Common Ground».

As they are dependent on the amounts of incoming water, ecosystems of saline lakes are highly vulnerable to any factors that alter the balance of water input and evaporation. This causes their global degradation (Wurtsbaugh et al., 2017). A recent analysis of the 50-year dynamics of the Earth's surface covered with water has revealed that nearly 70% of observed changes are caused by the Aral Sea drying (Pekel et al., 2016). The authors claim that the Aral drying has been the largest anthropogenic disaster caused by decreased water input as a result of human activities. The Aral Sea catastrophe is not a unique event. Several presentations addressed the current status of Lake Urmia (Iran). This large water body of several thousand km^2 is drying at a high rate (Hassanzadeh et al., 2012). The issue of saline lake fragility under the conditions of ongoing climate change and increasing human impact is being one of the central discussion points. Strategies for minimising freshwater lakes salinisation and saline lakes drying are being developed (Zadereev, 2018).

Saline waters are often used for therapeutic purposes. The Dead Sea (Israel) is the worldwide known site. Building health resorts on the shores of saline lakes is common practice in all countries that have them on their territories. A number of oral and poster presentations addressed the problem of research into new therapeutically active compounds in saline lakes. The most promising avenue in this area is related to antibiotics. Extreme habitats are prospective study sites where new species capable of producing antibiotics and other valuable substances can be discovered (Oren, 2018).

Salt lake water contains large amounts of precious elements and minerals which are of interest to industrial mining (Zheng, 2014). A special section was dedicated to saline water geochemistry and technologies used to obtain different elements and compounds.

Traditionally, the best oral and poster presentations by young scientists were awarded with Bill Williams Prize in commemoration of the prominent Australian limnologist. The best oral presentation from a young scientist award went to the Chinese researcher Long Li for the talk on the technology to obtain lithium from saline water. The best poster presentation was by the Russian scientist Elena Anufriieva on seed shrimp (ostracods) in hypersaline lakes in the Crimea. Two young scientists (from Kazakhstan and Belgium) received the Prize established by the ISSLR president, the Chinese geologist and limnologist Mianping Zheng. It was the first time this prize has ever been awarded.

In total, there were 81 oral and 57 poster presentations made at 11 sections. The papers included in this special issue touch upon a number of topical problems. Of primary importance is the research into the effect of salinity on species composition in natural aquatic ecosystems. The article by Elena Anufriieva and Nickolai Shadrin presents an analysis of the diversity of fauna in the Crimean hypersaline water bodies. The authors have collected and analysed data on more than 50 hypersaline water bodies, including the Sivash (the Sea of Azov), the largest hypersaline lagoon in the world. The variety of phyla and classes within a particular range of salinity was shown to decrease significantly with an increase in salinity; 8 classes in 3 phyla can withstand salinities above 100 g/L, and only 4 classes within 1 phylum occurred at salinities above 200 g/L. An important generalisation is that in the range

of 50–120 g/L, the number of species is mainly determined by a different set of factors. Thus, in spite of the fact that salinity is often considered to be the major factor determining the trophic chain structure and plankton species composition, in a wide range of salinities other abiotic and biotic factors influence critically ecosystem functions. It may lead to alternative ecosystem conditions under similar levels of salinity.

In their article, the researchers from Transbaikal Ekaterina Afonina and Natalia Tashlykova describe the distinctive features of plankton communities in the Torey Lakes. Lakes Barun-Torey and Zun-Torey, the largest water bodies in Zabaikalsky Krai, are characterised by long-term cyclic changes in the water level and salinity. The authors examined the planktonic coenoses of these lakes which were in different hydrological phases: Barun-Torey was in the initial filling phase, and Zun-Torey was in the shallowing phase. Considerable differences were observed between the compositions and structures of the phyto- and zooplankton communities, which were determined by the water salinity. Freshwater and euryhaline species were dominant in the small oligohaline lakes on the bottom of Lake Barun-Torey. In polyhaline Lake Zun-Torey, euryhaline and halophilic species dominated. The number of identified phyto- and zooplanknon taxa decreased with the salinity growth. Such water bodies as the Torey Lakes with frequent changes of the salinity level are unique natural laboratories to explore ecosystem responses to salinity alterations.

Alexander Tolomeev et al. studied shifts in the species composition and biomass of zoobenthos in saline Lake Shira that have occured over the last 65 years. The authors concluded that the amphipod *Gammarus lacustris* dominated zoobenthos in the early fifties of the 20th century and it is still a dominating species. In contrast, chironomid species that dominate now were not found in benthic fauna 65 years ago. Biomass values of Chironomidae (6.8 ± 3.11 g/m^2) and *G. lacustris* (4.4 ± 1.01 g/m^2) are several times smaller now compared to those obtained 65 years ago. In general, the data on a relatively small number of benthic species in Shira Lake (15 species) agree with normal pattern that species richness decreases in inland waters with salinities above 15 g/L.

Another approach to examining the impact of salinity on plankton species composition is used in paeleolimnological studies. Galina Bolobanshchikova et al. performed a comparative analysis of diatoms in the bottom sediments of Lake Shira and Lake Utichye-3 (Khakassia, Russia). The results showed that the species compositions in both lakes have changed several times. In the bottom sediments of both lakes freshwater, brackish and marine species were discovered. The authors come to a conclusion that the climatic conditions in the region where the lakes are situated, the water level and salinity have repeatedly undergone changes. For saline lakes, paeleolimnological studies provide information on fluctuations in salinity and related alterations in the species composition of lake communities.

The role of microbial communities in functioning saline lakes is very important, and several articles in this issue discuss it. The article by Denis Rogozin et al. presents the results of laboratory experiments on determining the growth rate of purple sulphur bacteria isolated from the chemocline of the saline meromictic Lake Shira. In many meromictic lakes these bacteria as well as other species of sulphur bacteria inhabiting the chemocline are major consumers of hydrogen sulphide, a compound that affects the functioning of the entire ecosystem. The authors examined the dynamics of bacterial growth at low temperatures and discovered that a rise in temperature to +8 °C caused an increase of bacterial abundance. These

results obtained under laboratory conditions are consistent with the observations of the lake ecosystem and may be useful for constructing predictive mathematical models to forecast the abundance of microorganisms determining ecosystem functioning.

Valentina Budagaeva and Darima Barkhutova observed the role of microbial communities in mineral formation in the thermal springs in the Baikal region. The authors used X-ray diffractometry (XRD) and scanning electron microscopy (SEM) to identify minerals formed in microbial communities in the outflows of alkaline nitrogen thermal springs characterised by high temperatures and pH values. The microbial communities were shown to participate in the formation of calcite, amorphous silica and opal. The formation of siliceous deposits can occur both extracellularly and intracellularly, which indicates that silicification can be both bioinduced and biocontrolled. Cyanobacteria directly participate in the precipitation of calcite by creating microzones with a high pH and in the formation of a glycocalyx, which absorbs Ca^{2+} ions. Bacterial exopolysaccharides can serve as a matrix for the nucleation of silicon from a solution. The topicality of such investigations is determined by the fact that microbial mats are considered to be the earliest Earth's ecosystems. They can be used as model systems in studies of microbial and biogeochemical interactions (cycles of carbon, nitrogen and sulphur) as well as microorganism-mineral interactions.

The article by Bayarma Tsydenova et.al. presents the data on the abundance and taxonomic composition of bacterioplankton in freshwater Lake Gusinoye (Buryatia, Russia) in the warm water zone of the Gusinoozerskaya Thermal Power Plant. The authors did not find significant differences between the chemical composition of water and abundance and diversity of bacteria in the zones subjected to and those not subjected to the thermal impact of the power plant. The maximum counts of bacterial cells were obtained close to the mouths of the inflowing rivers, where the water is enriched with biogenic elements.

In conclusion, we would like to acknowledge all the authors and reviewers for collaboration in preparing this special issue dedicated to the 13th International Conference on Salt Lake Research. We hope the readers of the articles will find them informative and useful for their own research. The next conference of the International Society for Salt Lake Research will take place in 2020 in Spain, the University of Murcia. It will be an excellent new opportunity to bring together the experts on saline lakes and discuss the advances in this fascinating research field.

Acknowledgements

This research was conducted in the framework of the state order of the Kovalevsky Institute of Marine Biological Research, Russian Academy of Science (No AAAA-A18-118021490093-4).

Список литературы

Dugan H.A., Bartlett S.L., Burke S.M., Doubek J.P., Krivak-Tetley F.E., Skaff N.K., Summers J.C., Farrell K.J., McCullough I.M., Morales-Williams A.M., Roberts D.C., Ouyang Z., Scordo F., Hanson P.C., Weathers K.C. (2017) Salting our freshwater lakes. *Proceedings of the National Academy of Sciences*, 114: 4453-4458

Golubkov S.M., Shadrin N.V., Golubkov M.S., Balushkina E.V., Litvinchuk L.F. (2018) Food chains and their dynamics in ecosystems of shallow lakes with different water salinities. *Russian Journal of Ecology*, 49: 442–448

Hassanzadeh E., Zarghami M., Hassanzadeh Y. (2012) Determining the main factors in declining the Urmia Lake level by using system dynamics modeling. *Water Resources Management*, 26: 129-145

Jeppesen E., Brucet S., Naselli-Flores L., Papastergiadou E., Stefanidis K., Noges T., Noges P., Attayde J.L., Zohary T., Coppens J., Bucak T. (2015) Ecological impacts of global warming and water abstraction on lakes and reservoirs due to changes in water level and related changes in salinity. *Hydrobiologia*, 750: 201-227

Namsaraev Z., Shadrin N., Zheng M., Oren A. (2015) Prof. Bair Namsaraev. *Chinese Journal of Oceanology and Limnology*, 33: 1353

Oren A. (2018) Physiology and biochemistry of halophilic microorganisms. *Introduction to Salt Lake Sciences.* Mianping Zheng, Tianlong Deng, Aharon Oren (eds.) Beijing, Science Press, p. 143-153

Pekel J.F., Cottam A., Gorelick N., Belward A.S. (2016) High resolution mapping of global surface water and its long-term changes. *Nature*, 540: 418-422

Shadrin N. (2018) Hypersaline lakes as the polyextreme habitats for life. *Introduction to Salt Lake Sciences.* Mianping Zheng, Tianlong Deng, Aharon Oren (eds.) Beijing, Science Press, p. 180-187

Thornton J.A., Slawski T.M., Lin H. (2015) Salinization: the ultimate threat to temperate lakes, with particular reference to Southeastern Wisconsin (USA). *Chinese Journal of Oceanology and Limnology*, 33: 1461-1475

Wurtsbaugh W.A., Berry T.S. (1990) Cascading effects of decreased salinity on the plankton chemistry, and physics of the Great Salt Lake (Utah). *Canadian Journal of Fisheries and Aquatic Sciences*, 47: 100-109

Wurtsbaugh W.A., Miller C., Null S.E., DeRose R.J., Wilcock P., Hahnenberger M., Howe F., Moore J. (2017) Decline of the world's saline lakes. *Nature Geoscience*, 10: 816–821

Zadereev E. (2018) Salt lakes, surrounding environments and environmental management. *Introduction to Salt Lake Sciences*. Mianping Zheng, Tianlong Deng, Aharon Oren (ed.) Beijing, Science Press, p. 172-179

Zheng M. (2014) *Saline lakes and salt basin deposits in China*. Beijing, Science Press, 321 p.